SEARCHING FOR HIGGS BOSONS ON LHC
USING b-TAGGING

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ABSTRACT

We demonstrate that the detection of the SM and MSSM Higgs bosons will be possible at the LHC via $t\bar{t}b\bar{b}$ and $b\bar{b}b\bar{b}$ final state, provided b-tagging can be performed with good efficiency and purity.

1. Introduction

Understanding the Higgs sector is one of the fundamental missions of future high energy colliders such as the LHC. However, options for detection of the Standard Model (SM) Higgs boson, ϕ^0, are limited to rare $\gamma\gamma$ decay chanel if m_{ϕ^0} lies between 80 GeV and 130 GeV. The Higgs bosons of the Minimal Supersymmetric Standard Model (MSSM) is even harder to find. In fact, there may be a window of m_A–$\tan\beta$ parameter space, in which no MSSM Higgs boson would be seen either at LEP-II or at the LHC.

Clearly, the establishment of viable techniques for detection of the Higgs bosons in its main decay mode in the intermediate mass region, $h \rightarrow b\bar{b}$, would be highly desirable. In this talk, we present our works[1] on using b-tagging to search for Higgs bonsons.

The basic idea is to look for Higgs bosons produced associated with $t\bar{t}$ or $b\bar{b}$, which then decays into $b\bar{b}$, hence the final state is $t\bar{t}b\bar{b}$ or $b\bar{b}b\bar{b}$. In either case, there will be four b-quarks in the final state. By tagging three or more b's, QCD background can be suppressed and the detection of the Higgs mass peak is possible.

2. MonteCarlo Simultion

The major background to the process that we discussed is of two types: 1)Inpurity backgrounds: $b\bar{b}g$ or $t\bar{t}$, $t\bar{t}g$ production with one of the gluons or light quarks in the final state being mistagged as a b-jet; 2) Irreducible backgrounds: direct QCD

production of $t\bar{t}b\bar{b}$ or $b\bar{b}b\bar{b}$. They are of the same order of magnitude.

When Higgs mass is close to m_Z, $t\bar{t}Z$ background to $t\bar{t}h$ are relevant, but Higgs peak will not be confused as a Z peak due to smaller branching ratio of $Z \rightarrow b\bar{b}$. Other types of backgrounds are considered but are negligilbe.

For $t\bar{t}b\bar{b}$ final states, we always require one of the top quarks to decay semilepton-ically so the event can be easily triggered on the lepton, we also require tagging three or all four b-jets. For $b\bar{b}b\bar{b}$ final states, we simply require tagging three b's, special triggers may have to be designed.

We did the tree level parton model MonteCarlo simulation of both the signal and the background with the K factor put in. Semileptonic b decays, which will change the $b\bar{b}$ invariant mass distribution due to missing momenta from the neutrino, is taken into account in our latest work. This will bring our parton level simulation much closer to jet level simulation.

For $b\bar{b}b\bar{b}$ channel, the singal/background ratio is very small in some cases even though the singal is statistically 5σ, we discussed the procedure needed to recover such a weak Higgs peak from the overwhelming background and made positive conclusions.

3. Result

We will briefly describe our result here and refer to our paper for detailed description.

We assume 30% and b-tagging efficiency and 1% of mistagging probability. (See our paper [1] for detailed description of cuts.) With several years of running at $100 fb^{-1}$ per year, the $t\bar{t}b\bar{b}$ chanel can be used to discover the SM Higgs up to 110-120GeV, and can be combined with the Wbb chanel[2]. This is complementary to the $\gamma\gamma$ chanel, which gets worse when Higgs is lighter.

With $100 fb^{-1}$, at 4σ level, MSSM Higgs h can be dicovered for a large part of parameter region and A for moderate $\tan\beta$ through $t\bar{t}b\bar{b}$ chanel. In a large triangle region for high $\tan\beta$ and moderate m_A, h and A or H and A can be simualtaneously discovered via $b\bar{b}b\bar{b}$ final states. The window which is mentioned ealier is now covered. In a more optimistic senario, $200 fb^{-1}$ with 40% b-tagging efficiency and same purity, the above two chanels alone can cover essentially all the MSSM parameter space, and often several Higgs bonsons can be discovered via several chanels on LHC.

4. Conclusion

The very great promise of these modes makes it virtually mandatory that the detector collaborations at the LHC find a way to perform b-tagging with the required efficiency and purity in the multi-event-per-crossing environment that will prevail for

high instantaneous luminosity at the LHC.

5. References

1. Jin Dai, J. Gunion and R. Vega, *Phys. Rev. Lett.* **71** (1993) 2699; *Phys. Lett.* **B315** (1993) 355; *Phys. Lett.* **B345** (1995) 29, and references therein.
2. A. Stange, W. Marciano and S. Willenbrock, *Phys. Rev.* **D49** (1994) 1354, *Phys. Rev.* **D50** (1994) 4491.